DIFFUSION THROUGH MEMBRANES

BY

MARVIN EUGENE WYMAN

A.B., Saint Olaf College, 1942
M.S., University of Illinois, 1943

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN PHYSICS
IN THE GRADUATE COLLEGE OF THE
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A study of the process of diffusion through collodion membranes was made using radioactive tracers. The transport rate of phosphoric acid was determined by measuring the radioactivity of the solution as the phosphoric acid containing radioactive phosphorus 32 moved through the membrane. The following results were obtained:

1. The transport rate in per cent per minute was measured for various concentrations of phosphoric acid. The transport rate increased rather slowly as the concentration was increased. In the concentration region of 10^{-4} molar to 10^{-2} molar phosphoric acid the transport rate showed a more marked increase with concentration. A plot of the transport rate in per cent per minute versus concentration appears as an "S" shaped function.

2. An explanation of this curve was attempted by associating it with the molecular and ionic composition of the phosphoric acid. If ionic and molecular diffusion are independent and have constant diffusion coefficients one can predict a similarly shaped curve. This predicted curve is displaced toward the higher concentration region in the transport rate versus concentration graph. If the dissociation constant were reduced by a factor of 30, there would be good agreement.

3. A discussion of the possibility of error in the dissociation constant is made. Measurements of the transport rate as affected by retarding fields indicate that the dissociation constant as determined by pH measurements is correct. A simple theory of the retarding field effect is presented.

4. Since the phenomenon is not describable as that of a membrane with a constant diffusion coefficient for ions and a constant diffusion coefficient for molecules, other factors were investigated. If the membrane properties for diffusion exist because of fixed charge groups, one should notice a different transport rate with an increase in ionic strength. An increase

in the per cent transported per minute was observed when the phosphoric acid concentration was held constant but the ionic content of the solution was increased by neutral salts. Sodium bromide and potassium chloride were used to increase the ionic strength. The increase in the transport rate from the ions of neutral salts was not as great as the increase observed from the increase in concentration of phosphoric acid.

5. An increase in the per cent transported per minute was observed as the hydrogen ion concentration was increased when the phosphoric acid concentration and ionic strength were held constant.

6. Using the same membrane, the same curve of per cent transported per minute versus concentration was obtained for both of the following experiments:

a) Transport rate of phosphoric acid measured as it moved through the membrane into water, the acid concentration increased by phosphoric acid.

b) Transport rate of phosphoric acid measured as it moved through the membrane into water, a small concentration of phosphoric acid held constant and the acid concentration increased by hydrochloric acid.

7. An oxidized membrane (one which contains many fixed anion groups) required higher concentrations to show a sharp increase in the per cent transported per minute than an unoxidized membrane (one which contains few fixed anion groups).

VITA

Marvin Eugene Wyman was born in North Branch, Minnesota, on April 9, 1921. Most of his early life was spent in North St. Paul, Minnesota, where he was graduated from high school. He attended St. Olaf College from September 1938 until June 1942, when he received his A.B. degree in Physics *magna cum laude.* His graduate work was done at the University of Illinois from September 1942 to May 1944 and from September 1946 until September 1949. The M.S. degree was granted to him in Physics by the University of Illinois in October 1943. He taught part time in the Physics Department at the University of Illinois during the time of his graduate work there. During the second world war, while in the U. S. Navy, he worked for about one and one half years with the Manhatten district project at Los Alamos.

He was a member of The Honors Society of St. Olaf College and is a member of *Sigma Xi.*